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Guidelines for Surface Water Quality

Vol. 1 Inorganic Chemical Substances

PREAMBLE

Stewart W. Reeder

INLAND WATERS DIRECTORATE,
WATER QUALITY BRANCH,
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Office of Water Quality Objectives and Standards

To the Reader:

This document has been developed to provide technical guidance to water resources managers who wish to establish multiple-use water quality objectives specific to individual water quality management areas. Emphasis has been placed on those naturally occurring and common toxic substances and on man-made persistent, toxic and bioaccumulative compounds that inadvertently have contaminated Canada's waterways.

The proposed objectives represent scientific judgments based upon the best available information relevant to Canadian surface waters on the relationships between toxic substances and water use and on the concentration-effect relationships between toxic substances and biological or environmental receptors. They should not be used as absolute values for water quality but with considered judgment and with an understanding of their development. The judgment associated with their use should include a thorough knowledge of the natural quality of the water under consideration, the kinds of organisms that it contains, the association of naturally occurring organisms with the particular organisms described in the document upon which the objectives have been formulated, and the local hydrological conditions. It can be expected that these proposed water use-objectives will change in the future as our knowledge and perception of the intricacies of water improve.

National water quality objectives can never be developed to meet the individual water use needs of each of Canada's waterways – the natural variability of the waters and of the organisms living within these waters can never be identified with a single numerical value. It is hoped, however, that a single numerical value can be formulated to protect the most critical receptors of multiple-use waterways which, in turn, will protect all other receptors.

The document, as presented, was designed to allow for additions and up-date as new information becomes available and as new pollutants are recognized. Every effort will be made to keep it current.

Reference materials used for this document are stored on a computer data file. This information is available to all interested persons by contacting the Water Quality Branch, Fisheries and Environment Canada, Ottawa, Ontario. K1A 0E7. Telephone (819) 997-1920 and Telex 053-3799.

S. W. Reeder
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Foreword

The Federal Government's *Policy Statement on Inland Waters* of 1977 provides guidance to water managers on all programs related to inland waters. Some elements of this policy statement relevant to the development and setting of water quality objectives are: (1) the Federal Government is committed to the restoration and protection of water quality and the enhancement of aquatic ecosystems through the development of water quality objectives to protect water uses, and (2) the Federal Government is committed to addressing most water problems through a joint, cooperative federal-provincial approach.

The publication *Guidelines for Surface Water Quality* was developed to provide to water managers the scientific basis for formulating water quality objectives specific to water management areas. It, therefore, deals with the effects of those basic water constituents and pollutants that are considered most significant to water users in the context of our present knowledge and experience. For each basic water constituent or pollutant, there are recommended levels for a water quality to provide for the protection of public water supplies, agricultural water supplies, aquatic life, wildlife, aesthetics and recreation, and water supplies for the food industries. There is a rationale supporting each of the recommended levels with listed references cited in the development of the recommendations.

The thrust of this document is to ensure adequate protection of our water resources for the greatest social and economic benefit of all Canadians, as well as to achieve a certain degree of uniformity in water quality objectives across the nation to meet the goal of a safe and acceptable water quality for all water users.

Guidelines presented in this document for the development of recommended levels of water quality on a basin by basin basis are presented under the heading "Concepts of the Use of Water Quality Objectives Specific to Water Uses."

N.H. James
Director General
Inland Waters Directorate

Preface

The Federal Government Organization Act of 1970 established the authority to adopt objectives and standards relating to environmental quality and to control pollution.

In 1971, the Subcommittee on Water Quality of the Interdepartmental Committee on Water authorized the establishment of a Working Group to develop a set of water quality guidelines for the surface waters of Canada.

The Working Group presented the results of its examination and investigation in *Guidelines for Water Quality Objectives and Standards*, published as Technical Bulletin No. 67 of the Inland Waters Directorate, Department of the Environment, in 1972. This technical bulletin is a preliminary report which served as the foundation for the preparation of a more detailed document and also served as a reference during the interim period. These guidelines are a summary of mainly international sources of scientific information. They stress the requirements for man's specific uses of water and the conditions that must be met to preserve the whole of the aquatic environment.

The more detailed document presented here is a response to the *Federal Policy Statement on Inland Waters* of 1977 in which the Government of Canada resolved to restore and protect water quality by providing water quality objectives according to water use.

The *Guidelines for Surface Water Quality* will be expanded in the future to include objectives for all constituents deemed necessary to protect each of the designated water uses. It will also be upgraded periodically to reflect pertinent new information. Until water quality use-objectives are developed for those constituents not included in this document, information relating to their effects on water uses may be found by referring to the "Published Surface Water Quality Limits for Specific Water Uses" section of this document.

Contents

Page

LETTER TO THE READER iii

FOREWORD v

PREFACE vii

ABSTRACT xi

RÉSUMÉ xi

ACKNOWLEDGMENTS xii

CANADIAN RECOMMENDED SURFACE WATER QUALITY OBJECTIVES xiii

INTRODUCTION 1

PRESENTATION OF MATERIAL 2

CONCEPTS OF THE USE OF WATER QUALITY OBJECTIVES SPECIFIC TO WATER USES 2
- Water quality use-objectives 2
- Limitations of water quality use-objectives 3
- Application of water quality use-objectives to water pollution control programs 3

PUBLISHED SURFACE WATER QUALITY LIMITS FOR SPECIFIC WATER USES 5

Tables

Published Surface Water Quality Limits for:

1. Public Water Supply 7

2. Aquatic Life 10

3. Wildlife 14

4. Agriculture 16

5. Aesthetics and Recreation 20

Abstract

This report is the introduction to a series of water quality guidelines, to be published in three volumes as they become available. Volume 1 deals with inorganic chemical substances, Volume 2 with organic chemical substances and Volume 3 with physical, microbiological and radiological characteristics.

The guidelines provide information on the source, occurrence and forms of basic water constituents and pollutants. A maximum concentration of the constituent is specified for each water use—public water supply, agricultural water supply, aquatic life, wildlife, aesthetics and recreation, and industrial water supply for the flood processing industry. These limits are based on up-to-date scientific information and each one is chosen according to the most sensitive use.

Each volume contains a preamble report similar to the present one. A master table lists the objectives for each water use for each of the constituents presented in that volume. The master table will be amended as additional information is produced and issued. The preamble also discusses the limitations of water quality use-objectives and their application in water pollution control programs. Tables for each water use compare published information from various sources on surface water quality limits.

Résumé

Le présent rapport sert d'introduction à une série de directives sur la qualité des eaux, lesquelles vont être publiées en trois volumes au fur et à mesure qu'elles seront établies. Le volume 1 va traiter des composés inorganiques, le volume 2, des composés organiques et le volume 3, des caractéristiques physiques, microbiologiques et radiologiques.

Les directives fournissent des renseignements sur les sources, les cas de présence et les formes des principaux constituants et polluants des eaux. La concentration maximale du constituant est précisée pour chaque utilisation des eaux — réserves d'eau publiques et agricoles, exigences des organismes aquatiques, de la faune, de l'esthétique et des loisirs, ainsi que besoins de l'industrie alimentaire. Ces limites sont fondées sur des données scientifiques récentes et chacune est déterminée en fonction de l'optimalisation de l'utilisation.

Chaque volume renferme un rapport préliminaire semblable au présent rapport. Un tableau général définit les objectifs de chaque utilisation particulière des eaux pour chacun des constituants présentés dans le volume. Ce tableau général va être modifié à mesure que des données supplémentaires sont obtenues et publiées. Le rapport préliminaire traite en outre des limitations des objectifs fixés pour les différentes utilisations des eaux et de leur mise en application dans les programmes de contrôle de la pollution des eaux. Les tableaux de chaque utilisation des eaux comparent les données sur les limites de la qualité des eaux de surface publiées par d'autres organismes.

Acknowledgments

The Water Quality Objectives and Standards Group are greteful for the assistance so freely given by numerous groups and individuals which provided reviews and comments, among them federal agencies with staff expertise in water quality sciences, including the Department of Agriculture, the Department of Indian and Northern Affairs, the Department of National Health and Welfare, and the Environmental Management Service and Environmental Protection Service of the Department of the Environment; and many others from government and research institutions, including the Department of Industry, Trade and Commerce, the Department of Public Works, the Department of Regional and Economic Expansion, the International Joint Commission, the National Water Research Institute and the National Research Council.

Much useful information including data and literature references was provided by the National Water Quality Data Bank (NAQUADAT), Canadian/Selective Dissemination of Information (Can/SDI), Bibliography of Agriculture (AGRICOLA), Water Resources Documentation (WATDOC), Canadian OnLine Enquiry (Can/OLE), Associate Committee on Scientific Criteria for Environmental Quality (ACSCEQ), and the libraries of the National Research Council, and the Departments of National Health and Welfare, Agriculture and Environment. We are indebted to Messrs. Ken Taylor and Edward Brien for their assistance in the pursuit of information and the screening of literature references.

MASTER TABLE

This table replaces the one that appeared on page xiii of "Guidelines for Surface Water Quality. Vol. 1. Inorganic Chemical Substances. Preamble".

MASTER TABLE
CANADIAN RECOMMENDED SURFACE FRESH WATER QUALITY OBJECTIVES[a]
(mg/L as total metal)

Constituent	Raw Public Water Supply	Aquatic Life and Wildlife		Agricultural Water Supply		Recreation	Food Processing
		Aquatic Life	Wildlife	Livestock	Irrigation		
Volume 1 – Inorganic Chemical Substances							
Arsenic	0.05	0.05	•[b]	0.5	0.1 (sensitive crop, sandy loam) 1.0 (sensitive crop, clay) 1.0 (tolerant crop, sandy loam) 2.0 (tolerant crop, clay)	0.05	0.05
Cadmium	0.01	0.0002	•	0.02	0.01	0.01	0.01
Chromium	0.1	0.04	0.04	1.0	0.1	0.1	0.1
Copper	0.5	0.002	0.002	1.0 (sheep and cattle present) 5.0 (all other cases)	0.2 (continuous use, sensitive plants) 1.0 (less sensitive plants) 5.0 (short-term use)	0.5	0.5
Lead	0.25 (conventional treatment) 0.05 (disinfection only)	0.005 (hardness <95 mg/L as $CaCO_3$) 0.01 (hardness >95 mg/L as $CaCO_3$; waters with sensitive species of fish) 0.03 (hardness >95 mg/L as $CaCO_3$; sensitive species of fish absent)	0.005 (hardness <95 mg/L as $CaCO_3$) 0.03 (hardness >95 mg/L as $CaCO_3$)	0.5 (horses present) 1.0 (horses absent)	5.0 (continuous use) 10.0 (intermittent use)	0.05	0.25 (conventional treatment) 0.05 (disinfection only)
Mercury	0.001	0.0001 (to protect consumers of fish) 0.0002 (where fish not eaten)	0.003 (see mercury content of fish for fish eaters)	0.003	no recommendation	0.001	0.001
Nickel	0.25 (conventional treatment)	0.025 (soft water) 0.25 (hardness >150 mg/L as $CaCO_3$)	0.025 (soft water) 0.25 (hardness >150 mg/L as $CaCO_3$)	5.0	0.2 (continuous use) 2.0 (intermittent use)	0.25	0.25
Selenium	0.05 (simple treatment) 0.25 (conventional treatment)	0.01	0.01	0.02 minimum 0.05 maximum	0.02 (continuous use) 0.05 (intermittent use)	0.05	0.05 (simple treatment) 0.25 (conventional treatment)
Silver	0.05 (no treatment or simple treatment) 0.2 (conventional treatment)	0.0001	•	•	•	0.05	0.05 (simple treatment) 0.2 (conventional treatment)
Zinc	5.0 (simple treatment) 10.0 (conventional treatment)	0.05 (hardness 0–120 mg/L as $CaCO_3$) 0.10 (hardness 120–180 mg/L as $CaCO_3$) 0.20 (hardness 180–300 mg/L as $CaCO_3$) 0.30 (hardness >300 mg/L as $CaCO_3$)	0.05 (hardness 0–120 mg/L as $CaCO_3$) 0.10 (hardness 120–180 mg/L as $CaCO_3$) 0.20 (hardness 180–300 mg/L as $CaCO_3$) 0.30 (hardness >300 mg/L as $CaCO_3$)	50.0	1.0 (soils pH <6.5) 5.0 (soils pH >6.5)	5.0	5.0 (simple treatment) 10.0 (conventional treatment)

(a) Table will be expanded as new limits are developed and issued.
(b) Insufficient information to set a defensible limit.

MASTER TABLE
CANADIAN RECOMMENDED SURFACE WATER QUALITY OBJECTIVES [a]

Constituent		Public Water Supply	Aquatic Life and Wildlife		Agricultural Water Supply		Recreation and Aesthetics		Industry
			Aquatic Life	Wildlife	Livestock	Irrigation	Recreation	Aesthetics	Food Processing
Volume 1 - Inorganic Chemical Substances									
Arsenic, total	mg/L	0.05	0.05	*[b]	0.5	0.1 to 2.0 [d]	0.05	–	0.05
Cadmium, total	mg/L	0.01	0.0002	*	0.02	0.01	0.01	–	0.01
Chromium, total	mg/L	0.1	0.04	0.04	1.0	0.1	0.1	–	0.1
Copper, total	mg/L								
Cyanide, total	mg/L								
Lead, total	mg/L	0.05	.005-0.02	*	0.5	5.0	0.05	–	0.05
Mercury, total	mg/L	0.001	0.0002	0.003	0.003	*	0.001	–	0.001
Nickel, total	mg/L	0.2	0.03 [c]	0.025	5.0	0.2 to 2.0 [e]	0.2	–	0.2
Selenium, total	mg/L	0.05	0.01	0.01	0.05	0.02	0.05	–	0.05
Silver, total	mg/L	0.05	0.0001	*	*	*	0.05	–	0.05

(a) Table will be expanded as new limits are developed and issued.
(b) Insufficient information to set a defensible limit.
(c) <0.03 where copper synergism can occur.
(d) Depending on soil type and crop.
(e) 2.0 for intermittent use.

Guidelines for Surface Water Quality

Vol. 1. Inorganic Chemical Substances. Preamble

Stewart W. Reeder

INTRODUCTION

The Federal Government Organization Act in 1970 brought to focus the need to protect and enhance the quality of the natural environment, including water, air and soil quality. It also established the authority to adopt objectives and standards relating to environmental quality and to control pollution.

Since that time, federal and provincial governments have produced over 300 pieces of pollution control legislation or amendments to existing legislation designed to provide protection from pollutants affecting the quality of the Canadian environment.

In addition to the legislation, the government of Canada has approved a *Federal Policy Statement on Inland Waters,* which provides guidance to water managers in the federal service on all programs dealing with inland waters. Elements of the policy statement that are directly relevant to the setting of water quality objectives should be borne in mind:

1. The Federal Government is committed to the conservation, development and use of Canadian water resources for the greatest social and economic benefit of Canadians, including both present and future generations.

2. The Federal Government is committed to addressing most water problems through a joint, cooperative federal-provincial approach.

3. The Federal Government is committed to the restoration and protection of water quality and the enhancement of aquatic ecosystems through

   (a) the development of water quality objectives to protect water uses;

   (b) the application of national effluent regulations and guidelines to control pollution discharges at the source; and

   (c) the control of nutrients and chemical substances which can become dispersed in the environment.

These excerpts from the policy statement make it clear that the federal government considers the adoption of water quality objectives and the promulgation of regulations and guidelines as complementary and equally necessary in dealing with water quality management and pollution control. Water management planning, based on technical, social and economic considerations, provides for the protection of water quality according to water use. Therefore, water quality objectives are being developed to protect specific uses. The guidelines are considered necessary to ensure that proposed basin water quality objectives and the programs implemented to achieve them do, in fact, serve the identified uses. This document identifies the water quality use-objectives that must first be considered in order to allow water managers to readily identify the water quality requirements, which can then be stated as water quality objectives on a basin-by-basin basis.

It should be borne in mind at the same time that every reasonable effort should be made to control pollution discharges at their source, the water quality objectives notwithstanding. The federal policy statement, therefore, makes it clear that best practicable pollution control technology is to be applied on an industry-by-industry basis to meet the immediate and short-term needs for pollution control. Such regulations and guidelines would be continually upgraded as technology is improved. The implementation of such technology is considered a necessary part of doing business in Canada. Where such regulations may not satisfy the water quality as indicated in specific objectives, additional effluent requirements will be identified and negotiated on a case by case basis.

It is the purpose of this document, then, to provide a scientific basis for selecting water quality objectives that are related specifically to important designated uses. Otherwise, water quality objectives would be extremely arbitrary and would probably carry little guarantee of providing adequate aquatic environmental protection.

PRESENTATION OF MATERIAL

The document is designed to present the material in three separate volumes. Volume 1 deals with Inorganic Chemical Substances, Volume 2 with Organic Chemical Substances and Volume 3 with Physical, Microbiological and Radiological Characteristics.

The document presents information on substances that may occur in water, where data indicate potential harm to waters users. It is designed to facilitate updating as new scientific water quality information becomes available and as new contaminants are recognized.

Included in the document is a discussion of the limitations of water quality use-objectives and their application in water pollution control programs. A thorough understanding of these factors is a prerequisite for those involved in establishing water quality objectives for specific water resource areas.

The format for presenting water quality use-objectives includes a concise statement of the objectives for the particular water use, followed by a narrative of the sources, occurrence and form of the constituent in the environment; a rationale that includes justification for the designated use-objectives; and a listing of the references cited. Supporting data have been restricted to published data or data in press awaiting publication.

Water quality use-objectives are given for substances that commonly occur in water and that are known to be persistent toxicants. There are also objectives for man-made persistent, toxic and bioaccumulative compounds that have contaminated Canada's waterways. Any omissions should be construed to mean that water quality use-objectives for the omitted quality constituent are either in the process of being developed or sufficient scientific data are not presently available to develop them.

CONCEPTS OF THE USE OF WATER QUALITY OBJECTIVES SPECIFIC TO WATER USES

The aim of this section is to discuss the many factors that must be considered when using water quality use-objectives to formulate water quality objectives specific to water resource areas.

Water Quality Use-Objectives

Water quality use-objectives are designated concentrations of constituents that when not exceeded will protect a prescribed water use with an adequate degree of safety.

In some cases, water quality use-objectives for selective constituents, especially those constituents known to be bioaccumulative in tissues, may be designated as body burdens. This ensures protection for the consumers of receptor organisms. In cases where the level of such a constituent cannot be detected in water, the body burden objective ensures that a method for monitoring the presence of the constituent in the water environment is available.

In other instances, the water quality use-objectives may be expressed in terms of an appropriate indicator rather than in terms of the constituent itself. For example, the presence of bacteria of fecal origin (*E. coli*) in a given volume of water serves as an indicator of the probable presence of pathogenic bacteria.

The water quality use-objectives are based on total concentrations of constituents in unfiltered water samples. Total concentrations are recommended because:

1. Adequate toxicity data are not available for most of the chemical species of constituents present in natural waters.

2. The toxicities of many metal constituents in water correlate well with the "free ion" concentrations, but methods for measuring "free ion" concentrations routinely in water are not presently available.

3. Many constituents enter the water system adsorbed on, or absorbed in, particulate matter and are subsequently released to the water by chemical, physical and microbial action. Thus, toxicants which enter the water system as a part of particulate matter may also in some way contribute to the toxicity and eliminate an important segment of the food web.

4. At the present time there is sufficient information available to allow the determination of the fraction of the toxicants present in the suspended matter which is biologically available. The "total" value will thus represent a maximum limit for the biologically available material.

The word "objective" should not be used interchangeably with the words "criterion" and "standard". The word "objective" means a designated concentration of a constituent that when not exceeded, will protect an organism, a community of organisms, a prescribed water use, or a designated multiple-purpose water use with an adequate degree of safety. An objective, in some cases, may be a narrative statement instead of a constituent concentration. The objective is based on scientific concentration-effect

relationship information and when applied to multiple-purpose use water bodies, may be required to reflect prevailing local natural conditions, such as naturally occurring metal concentrations, or social and economic factors, or an additional degree of safety to particularly sensitive ecosystems. Criteria are the results of scientific investigations which are used to determine the suitability of water quality to support and protect a prescribed water use. A "standard", on the other hand, is a legally described concentration of a constituent established under statutory authority.

Limitations of Water Quality Use-Objectives

Because of the complexity of the interrelations involved in determining both the fate and deleterious effects of toxicants in the water environment, it has been possible to identify and quantify only a few of the variables influencing the toxicants of concern. Thus, it is important to be aware that there are limitations, and probably will be for some time, in the scientific data base used to develop the water quality use-objectives.

Ideally, in developing water quality objectives, one needs complete information on exposure-effect (cause-effect, exposure-response) relationships for all environmental factors, for different effects and for different community groups covering the whole range of receptors at all exposure levels. Unfortunately, this ideal situation is not met for any single toxicant and still less for combinations of toxicants (antagonism, synergism, addition).

For this reason, the water quality use-objectives delineated in this document are based on "best available scientific information". Therefore, they are not, nor can they be expected to be the last word on the quality of the water needed to ensure the protection of a specific use. Given these limitations, it is desirable and necessary that objectives be provided to give some assurance of an adequate level of protection for water users.

There are limitations associated with the extrapolation of acute exposure-effect (96-h LC_{50}) to exposure-no-effect (safe) limits. Judgmental discretion dictates that a substantial safety factor be employed when making such extrapolation to ensure the protection of all life stages of the test organism, as well as the protection of associated organisms within the aquatic environment that have not been tested and that may be more sensitive to the test constituent. Application factors are used to provide the degree of protection required. The application factors used to estimate the safe concentrations of toxicants in this document are as follows:

1. Where subtle and deleterious effects were noted at the lowest chronic dose level, an application factor of 0.2 is applied.
2. Where toxicants have been determined to be non-persistent (half-life of less than 8 weeks) or have non-accumulative effects, an application factor of 0.05 is applied.
3. Where toxicants have been determined to be persistent (half-life of greater than 8 weeks) or accumulative, an application factor of 0.01 is applied.

In a country as large as Canada, there is a wide variation in climate, geology, soils, and flora and fauna. Thus, it is impossible to formulate water quality objectives which will cover all receptors and all environmental conditions. It is, however, possible to formulate water quality objectives to protect the most critical receptors which, in turn, will protect all other receptors, if adequate monitoring and surveillance are undertaken to ensure the sufficiency of the objectives for the specific requirement.

Application of Water Quality Use-Objectives in Water Pollution Control Programs

In Canada, water pollution control strategies are used in accompaniment with water pollution control legislation. These strategies take into account the lack of understanding about the water environment and its protection, and endeavour to apply effectively the knowledge that does exist while searching for new information. The strategy for developing water quality objectives specific to water management basins applies this principle by advocating the use of best available scientific information, while recognizing the limitations as outlined above.

To ensure that the aim to protect the waters of Canada for the greatest social and economic benefit of all Canadians is strictly adhered to, the federal government policy contains a commitment to establish, jointly with the provinces, water quality objectives to preserve aquatic ecosystems and to protect the various uses of the water resources. To do this, the following basic principles should underlie all objective-setting exercises:

1. Any deterioration of water quality beyond certain limits, regardless of the cause, is undesirable.
2. Objectives must include environmental requirements, as well as requirements for human consumption and use.
3. Objectives must be of such clarity that an assessment of probable impacts of development on water quality can be evaluated.

In conjunction with these overriding principles, the following general provisions must be met as far as possible:

1. The quality and overall value of the waters of Canada are protected or enhanced to meet the requirements for all foreseeable uses of water, and that

   (a) the quality of any body of water and life-system functioning within that water body should not be allowed to deteriorate below minimum acceptable levels consistent with current knowledge and practicable technology, or, if below, the quality of the water body should be brought up to a minimum acceptable quality;

   (b) certain "high quality" bodies of water whose existing quality is substantially above existing requirements, should be maintained at their existing high levels of quality.

2. Where natural conditions are suitable, all bodies of water should be of sufficiently high quality to permit safe direct body contact.

3. All waters should meet minimum national or international standards and objectives (statutory, recommended or agreed) designed for the protection or enhancement of public health and well-being.

4. The quality of waters should be maintained so as not to impede an optimum sustainable economic yield of Canada's fishery resources compatible with other desired users of water.

5. All waters should be maintained free from any substances which pose a threat to the aquatic or human environment, or within concentration limits for all constituents designated under appropriate legislature respecting environmental contaminants. Such freedom or limitation should be corroborated by biological assessment.

6. All waters should be free from amounts of substances attributable to municipal, industrial and other discharges that will settle to form putrescent or otherwise objectionable deposits and that produce colour, odour and other conditions, to such a degree as to create a nuisance or in concentrations that are toxic or harmful to human, terrestrial or aquatic life.

7. All waters should be free from floating debris, oil, scum, and other floating materials attributable to municipal, industrial or other discharges (including those from ships and other water-borne vehicles) in amounts sufficient to cause unsightly or deleterious effects on water quality.

8. All waters should be free from nutrient substances derived from municipal, industrial, agricultural or other sources in concentrations or quantities that create nuisance growths of aquatic macrophytes and algae.

As stated before, it is recognized that it is not feasible to set specific water quality objectives for Canada's waters on a national basis because of the wide range of natural water quality across the nation and the resulting need to take into account the local conditions. The local conditions to be considered include actual and projected water uses, economic conditions, natural and prevailing levels of particular constituents, the presence or absence of sensitive important species, characteristics of the local biological community, temperature and weather, flow characteristics and synergistic and/or antagonistic effects of combinations of toxicants. It is desirable, however, to achieve a certain degree of uniformity in water quality objectives across the nation to meet the goal of a safe and acceptable water quality for all water uses.

The following framework plan is useful in developing water quality objectives for local water resource areas:

1. Identify local conditions, such as actual and projected water uses, economic consideration that may affect water uses, levels of particular constituents in point source inputs, natural and prevailing levels of particular constituents in the water, characteristics of the local biological community, presence or absence of sensitive important species, weather and temperature, and flow characteristics.

2. From a detailed study of the water quality use-objectives in conjunction with determined local conditions, identify in parametric and descriptive terms the water quality requirements that will ensure the protection of the most sensitive water use. These requirements will become the multiple purpose water quality use-objectives for the resource area.

3. Through a detailed assessment of the locally determined conditions in relation to the multiple purpose water quality use-objectives, establish water quality objectives which become specific to the local water resource area. The following guide may be used to determine the water quality objectives.

   (a) When the prevailing quality of the water in the resource area meets local requirements and also

meets or is better than the multiple purpose water quality use-objectives:

(i) If the prevailing water quality just meets the multiple purpose water quality use-objectives, they become the water quality objectives specific to the water resource area.

(ii) If the prevailing water quality is better than the multiple purpose water quality use-objectives, they may be upgraded to meet the prevailing water quality. The upgraded values then become the water quality objectives specific to the water resource area.

(b) When the prevailing water quality of the water in the resource area *does not* meet the local requirements nor the multiple purpose water quality use-objectives, the cause must be determined:

(i) If the cause can be rectified by source treatment or source control, the multiple purpose water quality use-objectives can become the water quality objectives specific to the water resource area.

(ii) If the cause cannot be amply rectified because of uncontrollable sources such as natural inputs, diffused source inputs, or economic constraints, the multiple purpose water quality use-objectives may require small adjustments to comply with the prevailing quality of the water before they become the water quality objectives specific to the resource area. If quality differences are large, however, a restriction of water uses is a prerequisite.

When the prevailing quality of the water in the resource area does not meet the multiple purpose water quality use-objectives and cannot be rectified by source treatment or source control, a major choice of options in the management of the resource area must be made. At this time it becomes necessary to obtain reliable estimates of the costs of controlling pollution and the costs (direct or indirect) of not controlling pollution. There could also be instances, for example, of pollution from natural sources where controls are not feasible or practicable. When all technical, social and economic facts have been identified and assessed, the final decision must be based on the best choice of objectives that are deemed to support the optimum use of the waters in the resource area.

The processes used in reaching the conclusion on the quality of the water in the resource area to best fit the desired social and economic conditions must always be considered as being cyclic. As pollution control technology advances, there must be a corresponding upgrading of the water quality objectives. The review of water quality objectives specific to resource areas should become a part of all water management programs.

PUBLISHED SURFACE WATER QUALITY LIMITS FOR SPECIFIC WATER USES

The aim of this section is to provide, in concise form, available published surface water quality information on specific water uses. The information is presented by constituent and by referenced sources.

Until water quality use-objectives are developed for those constituents not included in this document, information relating to their effects on water uses may be found in the accompanying tables. However, this information should be used with caution and in conjunction with a thorough knowledge of local conditions, backed up by a well-defined water quality monitoring program to ensure that the beneficial uses of the water are adequately protected.

The information is presented in five tables as follows.

Table 1 Public Water Supply
Table 2 Aquatic Life
Table 3 Wildlife
Table 4 Agricultural Water Supply
Table 5 Aesthetic and Recreation

Table 1. Published Surface Water Quality Limits for Public Water Supply

Parameter		Sources and Objectives[a]					
		U.S.S.R. 1970	Canada 1972	U.S. NAS/NAE 1973	Australia 1974	U.S. EPA 1976	I.J.C. Great Lakes 1974-76
CHEMICAL							
Inorganic							
Ammonia (N)	mg/L	2.0	0.5	0.5	0.1-0.5 (p.57) [b]	–	0.5
Arsenic (As)	mg/L	0.05 (As^{+3})	0.05	0.1	0.05	0.05	0.05
Barium (Ba)	mg/L	4.0	1.0	1.0	1.0	1.0	–
Boron (B)	mg/L	–	5.0	–	1.0	–	–
Cadmium (Cd)	mg/L	0.01	0.01	0.01	0.01	0.01	–
Calcium (Ca)	mg/L	–	200	–	200	–	–
Chloride (Cl)	mg/L	–	250	250	200-600 (p.57)	–	–
Chromium (Cr)	mg/L	0.5 (Cr^{+3}) 0.1 (Cr^{+6})	0.05 (Cr^{+6})	0.05 (Total)	0.05 (Cr^{+6})	0.05	0.05
Cobalt (Co)	mg/L	1.0	–	–	–	–	–
Copper (Cu)	mg/L	0.1	1.0	1.0	1.0	1.0	–
Fluoride (F)	mg/L	1.5	1.5	1.4-2.4 (p.66)	1.5	–	1.2
Hydrogen sulphide (H_2S)	mg/L	Undetectable	0.3	–	Undetectable	–	–
Iron, soluble (Fe)	mg/L	0.5	0.3	0.3	0.3	0.3	–
Lead (Pb)	mg/L	0.1	0.05	0.05	0.05	0.05	–
Magnesium (Mg)	mg/L	–	150	–	30 if $SO_4^{=}$ >250 150 if $SO_4^{=}$ <250	–	–
Manganese (Mn)	mg/L	–	0.05	0.05	0.05-0.10	0.05	–
Mercury, total (Hg)	mg/L	0.005	–	0.002	0.002	0.002	–
Molybdenum (Mo^{+6})	mg/L	0.5	–	–	–	–	–
Nitrate + Nitrite (N)	mg/L	–	10	10	10	10	–
Nitrite (N)	mg/L	–	–	1.0	–	–	–
Oxygen, dissolved (O_2)	mg/L	–	–	–	> 5.0 (p.58)	–	–
Phosphate (P)	mg/L	–	0.2 (PO_4^{-3})	–	0.2	–	–
Selenium (Se)	mg/L	0.001 (SeO_3)	0.01	0.01	0.01	0.01	0.01 (Total)
Silver (Ag)	mg/L	–	0.05	–	0.05	0.05	–
Solids, total dissolved (TDS)	mg/L	–	1000	–	–	–	–
Sulphate ($SO_4^{=}$)	mg/L	–	500	–	250	–	–
Vanadium (V^{+5})	mg/L	0.1	–	–	–	–	–
Zinc (Zn)	mg/L	1.0	5.0	5.0	5.0	5.0	–

Table 1. (Cont'd)

Parameter		Sources and Objectives[a]					
		U.S.S.R. 1970	Canada 1972	U.S. NAS/NAE 1973	Australia 1974	U.S. EPA 1976	I.J.C. Great Lakes 1974-76
Organic							
Organochlorine Pesticides							
Aldrin	mg/L	0.002	0.017	0.001	0.001	–	–
Chlordane	mg/L	–	0.003	0.003	0.003	–	–
DDT & metabolites	mg/L	0.1	0.042	0.05	0.05	–	–
Dieldrin	mg/L	–	0.017	0.001	0.001	–	–
Endrin	mg/L	–	0.001	0.0005	0.0005	0.0002	–
Heptachlor	mg/L	0.05	0.018	0.0001	0.0001	–	–
Heptachlor epoxide	mg/L	0.05	0.018	0.0001	0.0001	–	–
Lindane	mg/L	–	0.056	0.005	0.005	0.004	–
Methoxychlor	mg/L	–	0.034	1.0	1.0	0.1	–
Toxaphene	mg/L	–	0.005	0.005	0.005	0.005	–
Organophosphate & Carbamate Pesticides							
Organophosphates & carbamates, total	mg/L	–	0.1	0.1	0.1	–	–
Herbicides							
2, 4-D	mg/L	–	–	0.02	0.02	0.1	–
2, 4, 5-T	mg/L	–	–	0.002	0.02	–	–
2, 4, 5-TP	mg/L	–	–	0.03	–	0.01	–
Herbicides, total	mg/L	–	0.1	–	–	–	–
Others							
Cyanide (CN)	mg/L	0.1	0.2	0.2	0.2	–	–
Detergents (MBA)	mg/L	0.5	0.5	0.5	0.5	–	–
Oil and grease	mg/L	0.1 (High S)	–	Undetectable	0.2	Undetectable	–
	mg/L	0.3 (Low S)					
Phenols	mg/L	0.001	0.002	0.001	0.001	0.001	0.001

Table 1. (Cont'd)

Parameter		Sources and Objectives[a]					
		U.S.S.R. 1970	Canada 1972	U.S. NAS/NAE 1973	Australia 1974	U.S. EPA 1976	I.J.C. Great Lakes 1974-76
PHYSICAL							
Colour	Pt-Co Units	–	15	75	15	75	–
Odour	TON	–	8	Unobjectionable	Unobjectionable	–	Unobjectionable
pH	Units	–	6.5-8.3	5.0-9.0	6.5-9.0	5.0-9.0	5.0-9.0
Taste		–	–	–	Unobjectionable	–	Unobjectionable
Temperature	°C	–	<15	Potable (p.89)	–	–	–
Turbidity	JTU	–	–	–	25	–	–
RADIOLOGICAL							
Radioactivity, total	pCi/L	–	10	(p. 84-85)	–	–	–
Gross alpha activity	pCi/L	–	–	–	3	–	–
Gross beta activity	pCi/L	–	–	–	30	–	–
Tritium	pCi/L	–	–	–	1000	–	–
MICROBIOLOGICAL							
Coliforms, total	Numbers/100 mL	–	5000	20000	5000	–	–
fecal	Numbers/100 mL	–	1000	2000	100	–	–

(a) U.S.S.R., 1970 – Maximum Permissible Concentrations (MPC) of Toxic Substances in Water for Sanitary-Household Use.
Canada, 1972 – Guidelines for Water Quality Objectives and Standards, Dept. of Environment, Inland Waters Directorate, Ottawa, Ontario, Tech. Bull. 67.
U.S., NAS/NAE, 1973 – Water Quality Criteria 1972. Environmental Protection Agency, Washington, D.C. Pub. EPA-R3-73-33.
Australia, 1974 – A Compilation of Australian Water Quality Criteria. Australian Water Resources Council Tech. Bull. No. 7, Canberra, Australia.
U.S., EPA, 1976 – Quality Criteria for Water. Environmental Protection Agency, Washington, D.C. Pub. EPA-440/9-76-023.
I.J.C. Great Lakes, 1974 to 1976 – Appendices "A" to Great Lakes Water Quality Board Reports 1974, 1975 and 1976 to the International Joint Commission, 100 Ouellette Ave., Windsor, Ontario.

(b) Page number(s) to specific reference as listed.

Table 2. Published Surface Water Quality Limits for Aquatic Life

Parameter		Sources and Objectives [a]				
		Canada 1972	U.S. NAS/NAE 1973	Australia 1974	U.S. EPA 1976	I.J.C. Great Lakes 1974-76
CHEMICAL						
Inorganic						
Ammonia (NH_3)	mg/L	–	0.02	0.1 of 96-h LC_{50} [b]	0.02	0.02
Arsenic (As)	mg/L	–	–	0.01 of 96-h LC_{50}	–	–
Beryllium (Be)	mg/L	–	–	–	0.11 (Soft water) 1.1 (Hard water)	–
Cadmium (Cd)	mg/L	0.05 of 10-d LC_{50}	0.0004 (Soft water for salmonids) 0.003 (Hard water for salmonids) 0.004 (Soft water for others) 0.03 (Hard water for others)	0.0004 (Soft water for salmonids) 0.003 (Hard water for salmonids) 0.004 (Soft water for others) 0.03 (Hard water for others)	0.0004 (Soft water for salmonids) 0.0012 (Hard water for salmonids) 0.004 (Soft water for others) 0.012 (Hard water for others)	0.0002 (Total)
Chlorine, total residual (Cl)	mg/L	–	0.003	–	0.002 (Salmonids) 0.01 (Others)	0.002
Chromium (Cr)	mg/L	0.13	0.05 (Total)	0.01 of 10-d LC_{50}	0.1	–
Copper (Cu)	mg/L	0.03 of 96-h LC_{50}	0.1 of 96-h LC_{50}	0.05 of 96-h LC_{50}	0.01 of 96-h LC_{50}	0.005 (Total)
Fluoride (F)	mg/L	–	–	–	–	1.0
Gases, dissolved	% Sat.	–	110 (% Atmospheric pressure)	–	110	–
Iron (Fe)	mg/L	–	–	–	1.0	0.3 (Total)
Lead (Pb)	mg/L	0.1 of 96-h LC_{50}	0.03	0.01 of 96-h LC_{50}	0.01 of 96-h LC_{50}	0.025 (Total)
Mercury (Hg)	mg/L	0.005 of 96-h LC_{50}	0.0002 (Total unfiltered)	0.0002 (Total unfiltered)	0.00005	0.0002 (Total filtered)
Nickel (Ni)	mg/L	–	0.02 of 96-h LC_{50}	0.05 of 96-h LC_{50}	0.01 of 96-h LC_{50}	0.025 (Total)
Oxygen, dissolved (O_2)	mg/L	(p. 103-105) [c]	(p. 134)	(p. 70)	>5.0	7.2 to 10 (p. 11, App. A, 1976)
Selenium (Se)	mg/L	–	–	–	0.01 of 96-h LC_{50}	0.02 of 96-h LC_{50}
Silver (Ag)	mg/L	–	–	–	0.01 of 96-h LC_{50}	0.0001 (Total)
Sulphide (H_2S)	mg/L	–	0.002	–	0.002	0.002

Table 2. (cont'd)

Parameter		Sources and Objectives [a]				
		Canada 1972	U.S. NAS/NAE 1973	Australia 1974	U.S. EPA 1976	I.J.C. Great Lakes 1974-76
Unspecified non-persistent toxicants		(p. 113)	–	–	–	0.05 of 96-h LC_{50}
Unspecified persistent toxicants		0.005 of 96-h LC_{50}	–	–	–	Substantially absent [d]
Zinc (Zn)	mg/L	0.01 of 96-h LC_{50}	0.005 of 96-h LC_{50}	0.005 of 96-h LC_{50}	0.01 of 96-h LC_{50}	0.03 (Total)
Organic						
Organochlorine Pesticides						
Aldrin	µg/L	0.005 of 96-h LC_{50}	0.01	0.01 of 96-h LC_{50}	–	–
Aldrin & dieldrin	µg/L	–	–	–	0.003	0.001
Chlordane	µg/L	0.005 of 96-h LC_{50}	0.04	0.01 of 96-h LC_{50}	0.01	0.06
DDT & metabolites	µg/L	0.005 of 96-h LC_{50}	0.002	0.01 of 96-h LC_{50}	–	0.003
Dieldrin	µg/L	0.005 of 96-h LC_{50}	0.005	0.01 of 96-h LC_{50}	–	–
Endrin	µg/L	0.005 of 96-h LC_{50}	0.002	0.01 of 96-h LC_{50}	0.004	0.002
Endosulfan	µg/L	0.005 of 96-h LC_{50}	0.003	0.01 of 96-h LC_{50}	0.003	–
Heptachlor/Heptachlor epoxide	µg/L	0.005 of 96-h LC_{50}	0.01	0.01 of 96-h LC_{50}	0.001	0.001
Lindane	µg/L	0.005 of 96-h LC_{50}	0.02	0.01 of 96-h LC_{50}	0.01	0.01
Methoxychlor	µg/L	0.005 of 96-h LC_{50}	0.005	0.01 of 96-h LC_{50}	0.03	0.04
Mirex & degradation products	µg/L	0.005 of 96-h LC_{50}	–	0.01 of 96-h LC_{50}	0.001	Substantially absent
Toxaphene	µg/L	0.005 of 96-h LC_{50}	0.01	0.01 of 96-h LC_{50}	0.005	0.008
Organophosphate and Carbamate Pesticides						
Carbaryl	µg/L	–	0.02	0.02	–	–
Ciodrin	µg/L	–	0.1	0.1	–	–
Coumaphos	µg/L	–	0.001	0.001	–	–
Demeton	µg/L	–	–	–	0.1	–
Diazinon	µg/L	–	0.009	0.009	–	0.08
Dichlorvos	µg/L	–	0.001	0.001	–	–
Dioxathion	µg/L	–	0.09	0.09	–	–
Disulfoton	µg/L	–	0.05	0.05	–	–
Dursban	µg/L	–	0.001	0.001	–	–
Ethion	µg/L	–	0.02	0.02	–	–
EPN	µg/L	–	0.06	0.06	–	–
Fenthion	µg/L	–	0.006	0.006	–	–
Guthion	µg/L	–	0.001	0.001	0.01	0.005

Table 2. (cont'd)

Parameter		Sources and Objectives [a]				
		Canada 1972	U.S. NAS/NAE 1973	Australia 1974	U.S. EPA 1976	I.J.C. Great Lakes 1974-76
Malathion	µg/L	–	0.008	0.008	0.1	–
Mevinphos	µg/L	–	0.002	0.002	–	–
Naled	µg/L	–	0.004	0.004	–	–
Oxydemeton Methyl	µg/L	–	0.4	0.4	–	–
Parathion	µg/L	–	0.0004	0.001	0.04	0.008
TEPP	µg/L	–	0.4	0.3	–	–
Trichlorphon	µg/L	–	0.002	0.002	–	–
Zectran	µg/L	–	0.1	0.1	–	–
Herbicides						
Aminotriazole	µg/L	–	300	300	–	–
Dalapon	µg/L	–	110	110	–	–
Dicamba	µg/L	–	200	0.2	–	–
Dichlobenil	µg/L	–	37	37	–	–
Dichlone	µg/L	–	0.2	0.7	–	–
Diquat	µg/L	–	0.5	0.5	–	–
Diuron	µg/L	–	1.6	1.6	–	–
2, 4-D	µg/L	–	4.0 (BEE)	4.0 (BEE)	–	–
Fenac	µg/L	–	45	45	–	–
Simazine	µg/L	–	10	10	–	–
2, 4, 5-TP	µg/L	–	2.5 (BEE)	2.5 (BEE)	–	–
Botanicals						
Allethrin	µg/L	–	0.002	0.002	–	–
Pyrethrum	µg/L	–	0.01	0.01	–	–
Rotenone	µg/L	–	10.0	10.0	–	–

Table 2. (cont'd)

Parameter		Sources and Objectives [a]				
		Canada 1972	U.S. NAS/NAE 1973	Australia 1974	U.S. EPA 1976	I.J.C. Great Lakes 1974-76
Others						
Cyanide, free (CN)	µg/L	–	5.0	0.1 of 96-h LC_{50}	5.0	5.0
Detergents	µg/L	–	200 (LAS)	0.05 of 96-h LC_{50}	–	–
Oil and Grease	µg/L	(p. 125-126)	0.05 of 96-h LC_{50}	0.05 of 96-h LC_{50}	0.1 of 96-h LC_{50}	0.09 of 96-h LC_{50}
Phenolics	µg/L	–	100	0.05 of 96-h LC_{50}	1.0	–
Phthalic Acid Esters, total						
PAE	µg/L	–	0.3	–	0.3	–
Dibutyl phthalate	µg/L	–	–	–	–	4.0
Di(2-ethylhexal) phthalate	µg/L	–	–	–	–	0.6
Other phthalic acid esters	µg/L	–	–	–	–	0.2
Polychlorinated Biphenyls (PCB)	µg/L	–	0.002	0.002	0.001	(p. 47, 1974)
Tainting Substances	µg/L	–	(p. 147-150)	–	–	(p. 196-208, 1974)
Unspecified Persistent Toxic Substances		0.005 of 96-h LC_{50}	–	–	–	Substantially absent
Unspecified Non-persistent Toxic Substances		(p. 113)	–	–	–	0.05 of 96-h LC_{50}
PHYSICAL						
Colour		–	(p. 130)	No undue increase	(p.101)	–
pH	Units	(p. 110)	(p. 141)	(p. 71)	6.5-9.0	6.0-9.0 ±0.5
Solids, settleable and suspended	mg/L	Natural seasonal maximum	(p. 129)	80	(p. 210)	<10% change in Secchi disc depth
Temperature	°C	<0.5 from normal	(p. 151-171)	(p.69-70)	(p. 420-446)	(p. 113-117, 1975)
MICROBIOLOGICAL						
Bacteria and viruses		(p. 127-128)	–	–	–	–

(a) Canada, 1972 – Guidelines for Water Quality Objectives and Standards. Dept. of Environment, Inland Waters Directorate, Ottawa, Ontario. Technical Bulletin 67.
U.S., NAS/NAE, 1973 – Water Quality Criteria 1972. Environmental Protection Agency, Washington, D.C. Pub. EPA-R3-73-33.
Australia, 1974 – A Compilation of Australian Water Quality Criteria. Australian Water Resources Council, Canberra, Australia. Technical Bull. No. 7.
U.S., EPA, 1976 – Quality Criteria for Water. Environmental Protection Agency, Washington, D.C. Pub. EPA-440/9-76-023.
I.J.C., Great Lakes, 1974-76 – Appendices "A" to Great Lakes Water Quality Board Reports 1974, 1975 and 1976 to the International Joint Commission, 100 Ouellette Ave., Windsor, Ontario.

(b) The value attained by multiplying the proposed application factor to the 96-h LC_{50} as determined by using the receiving water in question and the most sensitive important species in the locality as the test organism.

(c) Page(s) in publication as listed. Objective too complex to insert in table.

(d) Substantially absent–meaning less than detection levels as determined by the best scientific methodology available.

(e) Threshold level–level that produces no harmful effects in long-term exposure tests.

Table 3. Published Surface Water Quality Limits for Wildlife.

Parameter		Sources and Objectives [a]				
		Canada 1972	U.S. NAS/NAE 1973	Australia 1974	U.S. EPA 1976	I.J.C. Great Lakes 1974-76
CHEMICAL						
Inorganic						
Alkalinity	mg/L	Fluctuations <50	30 to 130 Fluctuations <50	–	–	–
Lead (Pb)		Substitute for lead shot	1.0 shot per 4 ft² in top 2 in. of sediment	–	–	–
Mercury (Hg)	mg/L	–	0.5 mg/kg in fish	0.5 mg/kg in aquatic organisms (wet wt.)	0.00005	0.5 mg/kg in whole fish (wet wt. basis)
Oxygen, dissolved (DO)		Maintain aerobic conditions	–	–	–	–
Organic						
Organochlorine Pesticides						
Aldrin, dieldrin, endrin, heptachlor, heptachlor epoxide, chlordane, lindane, benzene hexachloride, toxaphene and endosulfan	mg/kg	–	0.1 in whole fish (wet wt.) either singly or in combination.	–	–	–
DDT and metabolites	mg/kg	–	1.0 in any aquatic plants and animals (wet wt.)	–	–	–
Mirex plus degradation	mg/kg	–	–	–	–	Substantially absent [b] in aquatic organisms
Others						
Cyanide (CN)	µg/L	–	–	–	5.0	–
Oils		No visible floating oil	No visible floating oil	–	Surface virtually free	No visible film, sheen, or discolouration
Polychlorinated biphenyls	µg/L	–	Body burden should not increase	0.5 mg/kg in aquatic organisms	0.001	0.1 mg/kg in whole fish (wet wt.)

Table 3. (Cont'd)

Parameter	Sources and Objectives [a]				
	Canada 1972	U.S. NAS/NAE 1973	Australia 1974	U.S. EPA 1976	I.J.C. Great Lakes 1974-76
PHYSICAL					
pH units	7.0-9.2	7.0-9.2	7.0-9.2	–	–
Settleable substances	Minimized	Minimized	–	–	Free
Temperature	–	Avoid changes in natural freezing patterns	–	–	–
Toxic growths	Free of heavy algal growths	–	–	–	–
Turbidity and light penetration	<5% incident light at surface not to be exceeded on 7 consecutive days.	<10% change in compensation point	–	–	–

[a] Canada, 1972 – Guidelines for Water Quality Objectives and Standards. Dept. of Environment, Inland Waters Directorate, Ottawa, Ontario. Technical Bulletin 67.
U.S., NAS/NAE, 1973 – Water Quality Criteria 1972. Environmental Protection Agency, Washington, D.C., Pub. EPA-R3-73-33.
Australia, 1974 – A Compilation of Australian Water Quality Criteria. Australian Water Resources Council, Canberra, Australia, Tech. Bull. No. 7.
U.S. EPA, 1976 – Quality Criteria for Water Environmental Protection Agency, Washington, D.C. Pub. EPA-440/9-76-023.
I.J.C., Great Lakes, 1974-76 – Appendices "A" to Great Lakes Water Quality Board Reports 1974, 1975 and 1976 to the International Joint Commission, 100 Ouellette Avenue, Windsor, Ontario.

[b] Substantially absent–meaning less than detection levels as determined by the best scientific methodology available.

Table 4.1. Published Surface Water Quality Limits for Agriculture: Livestock Watering (including Wildlife Ungulates).

Parameter		Sources and Objectives[a]	
		U.S. NAS/NAE 1973	Australia 1972
CHEMICAL			
Inorganic			
Aluminum (Al)	mg/L	5.0	–
Arsenic (As)	mg/L	0.2	1.0
Boron (B)	mg/L	5.0	–
Cadmium (Cd)	mg/L	0.05	0.01
Calcium (Ca)	mg/L	–	1000
Chromium (Cr)	mg/L	1.0	1.0-5.0
Cobalt (Co)	mg/L	1.0	–
Copper (Cu)	mg/L	0.5	0.5-2.0
Fluoride (F)	mg/L	2.0	2.0
Iron (Fe)	mg/L	Diss. Fe seldom found at toxic levels naturally	10
Lead (Pb)	mg/L	0.1	0.5
Magnesium (Mg)	mg/L	–	250-500
Manganese (Mn)	mg/L	Not usually found at toxic levels naturally	–
Mercury (Hg)	mg/L	0.01 and 0.5 mg/kg in meat	0.002
Molybdenum (Mo)	mg/L	–	0.01
Nitrate + Nitrite ($NO_3^- + NO_2^-$)	mg/L	100	90-200 (as NO_3^-)
Nitrite (NO_2)	mg/L	10	10
Selenium (Se)	mg/L	0.05	0.02
Solids, total dissolved (TDS)	mg/L	3000	(p.121)
Sulphate ($SO_4^=$)	mg/L	–	1000
Vanadium (V)	mg/L	0.1	–
Zinc (Zn)	mg/L	25	20
Organic			
Organochlorine Pesticides			
Aldrin	mg/L	0.001	0.001
Chlordane	mg/L	0.003	0.003

Table 4.1. (Cont'd)

Parameter		Sources and Objectives[a] U.S. NAS/NAE 1973	Australia 1972
DDT & metabolites	mg/L	0.05	0.05
Dieldrin	mg/L	0.001	0.001
Endrin	mg/L	0.0005	0.0005
Heptachlor/Heptachlor epoxide	mg/L	0.0001	0.0001
Lindane	mg/L	0.005	0.005
Methoxychlor	mg/L	1.0	1.0
Toxaphene	mg/L	0.005	0.005
Organophosphate & carbamate pesticides			
Organophosphates & carbamates, total	mg/L	0.1	0.1
Herbicides			
2, 4-D	mg/L	0.02	0.02
2, 4, 5-T	mg/L	0.002	0.02
2, 4, 5-TP	mg/L	0.03	–
PHYSICAL			
Temperature	°C	–	(p. 129)
Toxic algae		Avoid heavy growths of blue-green algae	Avoid heavy growth of blue-green algae
RADIOLOGICAL			
Gross alpha activity	pCi/L	0.5	3.0 (p. 128)
Gross beta activity	pCi/L	5.0	30 (p. 128)
MICROBIOLOGICAL			
Coliforms, fecal (pathogenic organisms)	No./100 ml	Avoid contaminated areas	1000 (Monthly mean) 5000 (Any one sample)
Parasitic Organisms		Avoid contaminated areas	–

[a] See Table 4-2.

Table 4.2. Published Surface Water Quality Limits for Agriculture Irrigation.

Parameter		Sources and Objectives (a)		
		U.S. NAS/NAE 1973		
		All Soils Continuous Use	Neutral to Alkaline Fine-Textured Soils for 20 Years	Australia 1974
CHEMICAL				
Inorganic				
Aluminum (Al)	mg/L	5.0	20	5.0
Arsenic (As)	mg/L	0.1	2.0	0.1
Beryllium (Be)	mg/L	0.1	0.5	0.1
Biochemical Oxygen Demand (BOD)	mg/L	High values could deplete available oxygen		–
Boron (B)	mg/L	0.75 (Sensitive crops) 1.0 (Semitolerant crops) 2.0 (Tolerant crops)	2.0 (Sensitive crops) Higher values for less sensitive crops	(p. 105) (b)
Cadmium (Cd)	mg/L	0.01	0.05	0.01
Chloride (Cl)		(p. 328-329)	(p. 328-329)	(p. 107)
Chromium (Cr)	mg/L	0.1	1.0	1.0
Cobalt (Co)	mg/L	0.05	5.0	0.2
Chemical Oxygen Demand (COD)		High values could deplete available oxygen		–
Copper (Cu)	mg/L	0.2	5.0	0.2
Fluoride (F)	mg/L	1.0	15	1.0
Iron (Fe)	mg/L	5.0	20	1.0
Lead (Pb)	mg/L	5.0	10	5.0
Lithium (Li)	mg/L	2.5	2.5	2.5
	mg/L	0.075 Citrus	0.075 Citrus	0.1 Citrus
Manganese (Mn)	mg/L	0.2	10	0.5
Molybdenum (Mo)	mg/L	0.01	–	0.01
	mg/L	0.05 (Short term)	–	–
Nickel (Ni)	mg/L	0.2	2.0	0.2
Selenium (Se)	mg/L	0.02	0.02	0.02
Sodium (SAR)		Nomogram (p. 331)		Nomogram (p. 99)
Solids, Total Dissolved (TDS)	mg/L	(p. 324-328)		(p. 90)
Vanadium (V)	mg/L	0.1	1.0	–
Zinc (Zn)	mg/L	2.0	10	2.0

Table 4.2. (Cont'd)

Parameter		Sources and Objectives [a]		
		U.S. NAS/NAE 1973		
		All Soils Continuous Use	Neutral to Alkaline Fine-Textured Soils for 20 Years	Australia 1974
Organic				
Pesticides				
Herbicides		No documented toxic effects (Table V-15, p. 347)		No documented toxic effects (Table 4.10, p. 115)
PHYSICAL				
pH	units	4.5-9.0	4.5-9.0	4.5-9.0
Temperature		Avoid high and low temperature waters		Avoid high and low temperature waters
Solids, Suspended		Low to medium (p. 332)		Low to medium (p. 87)
RADIOLOGICAL				
Gross alpha activity	pCi/L	3	3	3
Gross beta activity	pCi/L	10	10	10
MICROBIOLOGICAL				
Coliforms, fecal	No./100 ml	1000	1000	1000 (Monthly mean) 4000 (Any one sample)

[a] U.S. NAS/NAE, 1973 – Water Quality Criteria 1972. Environmental Protection Agency, Washington, D.C. Pub. EPA-R3-73-33.
Australia, 1974 – A Compilation of Australian Water Quality Criteria. Australian Water Resources Council, Canberra, Australia, Tech. Bull. No. 7.

[b] Page(s) in publication as listed. Objective too complex to insert in table.

Table 5. Published Surface Water Quality Limits for Aesthetics and Recreation.

Parameters		Sources and Objectives [a]			
		Canada 1972	U.S. NAS/NAE 1973	Australia 1974	U.S. EPA 1976
AESTHETICS					
Materials that will settle to form objectionable deposits		Free	Virtually free	Free	Free
Floating debris, oil, grease, scum and other matter		Free	Virtually free	Free	Free
Substances producing objectionable colour, odour, taste, turbidity or foam		Free	Virtually free	Free	Free
Substances and conditions, or combinations thereof, in concentration which produce undesirable aquatic life		Free	Virtually free	Free	Free
RECREATION					
Chemical					
Body contact Toxic chemicals		Not to exceed emergency limits	Will not constitute a health risk; will not irritate skin or mucous membranes	Will not constitute a health risk	Must not produce adverse physiological responses
Physical					
Clarity		Secchi disc visible at 1.2 m (4 ft)	Allow detection of subsurface hazards or submerged bodies	Secchi disc visible at 1.2 m (4 ft)	–
Colour	Pt-Co Scale	100	–	–	–
Detergents, synthetic	mg/L	2 as ABS equiv.	–	–	–
Odour	TON	16	–	–	–
Oil and grease	mg/L	5.0	–	–	–
pH	units	6.5-8.3	6.5-8.3	6.5-8.3	5.0-9.0
Plankton concentration, total	No.org/L	<5000 over normal	–	–	–
Temperature	°C	15-30	15-35	20-30	–
Turbidity	JTU	5 to 50	–	–	–

Table 5. (Cont'd)

Parameters		Sources and Objectives [a]			
		Canada 1972	U.S. NAS/NAE 1973	Australia 1974	U.S. EPA 1976
Radiological					
Gross radioactivity	pCi/L	<10	–	–	–
Microbiological					
Coliforms, total	No./100 mL	500	–	–	–
Coliforms, fecal	No./100 mL	200	–	200	200 monthly log mean

[a] Canada, 1972 – Guidelines for Water Quality Objectives and Standards. Dept. of Environment, Inland Waters Directorate, Ottawa, Ontario, Tech. Bull. 67.
U.S., NAS/NAE, 1973 – Water Quality Criteria 1972. Environmental Protection Agency, Washington, D.C. Pub. EPA-R3-73-33.
Australia, 1974 – A Compilation of Australian Water Quality Criteria. Australian Water Resources Council, Canberra, Australia, Tech. Bull. No. 7.
U.S., EPA, 1976 – Quality Criteria for Water. Environmental Protection Agency, Washington, D.C. Pub. EPA-440/9-76-023.